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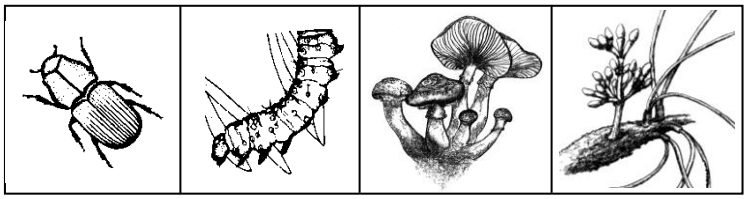

Report 15-05 **June 2015**

Analysis of Stand Susceptibility with Comprehensive Forest Inventory Plots in the Pryor and Wolf Mountains, Crow Indian Reservation

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Executive Summary

Comprehensive forest inventory plots within the Pryor and Wolf Mountains of the Crow Indian Reservation were utilized to evaluate stand-level hazard or susceptibility to bark beetle-caused tree mortality. In total, 414 fixed area plots that were 1/5th acre were last surveyed in 2006. Plots were distributed across 166,694 acres at a density of one plot every 0.6 miles or 400 acres. Data from these plots were modeled to current and future conditions using the Forest Vegetation Simulator and used to calculate beetle susceptibility ratings for each time period. Findings are presented separately for the different forest types within the Pryor and Wolf Mountains. Overall, more than half of the area surveyed within the Pryor Mountains (55%) rated at a high susceptibility to mountain pine beetle-attack in lodgepole pine forests. Similarly, majority of forested area surveyed within the Wolf Mountains (51%) rated at a high susceptibility to bark beetle-attack for the ponderosa pine forests. Thus, landscape-scale conditions are conducive to support a widespread bark beetle outbreak in each survey area when climatic conditions revert to the next long-term drought cycle. The distribution of susceptible stands was intermixed in both Pryor and Wolf Mountain survey areas. Data depicting typical stand attributes, by forest type and susceptibility ratings, are presented to depict current and anticipated future conditions for these areas. It is recommended that harvesting activities target stands that meet or exceed the average values for highly susceptible forests in each survey area. Additionally, it is recommended that harvesting activities be dispersed throughout the survey areas rather than clumped in a single location. Data projecting increased merchantable volume over the next decade can be compared to the potential risk of an insect outbreak to frequency of harvesting needed to meet management objectives. Specific harvesting methods available to enhance resilience to primary bark beetle and wildland fire disturbances are discussed.

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Introduction

The Crow Indian Reservation has forest resources that span the Pryor, Bighorn, and Wolf Mountain ranges in southeastern Montana. Forest resources in the Pryor and Wolf Mountains are actively managed while the Bighorns are not. Management objectives are to minimize damage from primary disturbance agents, including stand-replacing wildland fires and mountain pine beetles (MPB, *Dendroctonus ponderosae* Hopkins), to protect economic value of forest resources.

Severe and widespread outbreaks of MPB have occurred recently within the pine forests of western North America (Man 2012), including Montana (Gannon and Sontag 2009). However, little MPB or other bark beetle activity has occurred within the pine forests of the Crow Indian Reservation to-date (Egan 2014).

Tribal forest managers requested a detailed analysis of landscape-scale forest susceptibility to enhance decisions regarding harvesting locations to promote resilience to primary disturbances. The Tribal Council for the Crow Indian Reservation released an extensive set of forest inventory data for Forest Health Protection staff to support this analysis.

The goal of this study was to utilize tribal Comprehensive Forest Inventory (CFI) plot data to characterize stand-level patterns of forest susceptibility across the actively managed landscapes within the Pryor and Wolf Mountains to support location prioritization for harvest operations. Specific objectives were to 1) characterize current and future anticipated forest attributes; 2) estimate the current and future extent of forested area with various degrees of susceptibility to MPB and other bark beetles (i.e. *Ips* spp. in ponderosa pine systems); 3) describe current and future spatial pattern of susceptibility at a landscape-level; and 4) describe the modeled change in forest attributes that will occur over the next ten years.

Methods

Comprehensive forest inventory (CFI) plots are remeasured on a periodic cycle. Data collected within plots included common forest mensuration attributes (including tree species, diameter at breast height, height, sentinel tree growth rates, etc.) that are required as input for modeling within the Forest Vegetation Simulator (Dixon 2002).

A total of 414, $1/5^{th}$ acre (52.7-foot radius) permanent plots were most recently measured in 2006. These plots were distributed throughout 167,000-acre spatial extent at a density of one plot every 384 acres (or 0.6 square miles). Major forest species compositions vary in the Pryor and Wolf mountains; thus, these analyses were stratified by respective mountain ranges. Much of the data is also presented after stratifying by the dominant species (>50% of basal area) for all plots.

FVS modeling was incorporated to simulate stand growth from measurement period in 2006 to current 2016 values to depict baseline stand conditions (Dixon 2002). Minimal disturbances occurred throughout the study areas in the past decade; thus, the modeled current conditions are considered accurate. Subsequent forest growth was simulated at 10-year intervals to derive forest attributes at the 2026 and 2036 time periods. All standard parameters, including background mortality calculations, were utilized in this growth modeling. Forest attributes were described from this modeling.

Susceptibility to MPB disturbance was calculated for both lodgepole and ponderosa pine-dominated plots using scoring methods described in Randall et al. (2011). Attributes used for these hazard ratings include total basal area, quadratic mean diameter of pine $\geq$ 5" DBH, and species composition of pine basal area for trees $\geq$ 5" DBH.

Total area within susceptibility classes was estimated by extrapolating the proportion of plots within a given hazard class to the entire distribution of plots. Confidence intervals (CI) were calculated for these

estimates using binomial distributions at $\alpha = .05$ to represent 95% CIs using the Exact test in the 'Freq' procedure in the Statistical Analysis Software v9.4.

Pryor Mountain Results

In the Pryor Mountains, lodgepole pines frequently dominated the host composition within plots that had moderate and high stocking levels. Forest attributes from 2016-2036, as well as mean forest attribute changes anticipated in the subsequent ten years, are presented in Appendix A. In majority of plots surveyed, an estimated thirty thousand acres had attributes that were considered highly susceptible to MPB-attack in 2016 (Table 1). The proportion of highly susceptible area increased by 4% from 2016 to 2026, then slightly declined by 3% between 2026 and 2036 due to background mortality in the FVS models.

Table 1. Plot and area distribution of MPB susceptibility from 2016-2036 in the Pryor Mountains, Crow Indian Reservation

n = 139 plots are distributed throughout 56,647 acres in grid distribution with 1 plot every .6 square miles

Forest Type	Plots	Percent of all Plots	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Area Estimate (acres)	Lower CI Estimate (acres)	Upper CI Estimate (acres)
Lodgepole pine	81	58%	50%	66%	33,010	28,369	37,653
Douglas-fir	32	23%	16%	30%	13,041	9,075	17,005
Mixed Species	26	19%	12%	25%	10,596	6,922	14,269
2016 Mountain Pine Beetle Hazard Rating for Lodgepole Pine							
Low Hazard	34	24%	18%	32%	13,856	9,953	18,393
Moderate Hazard	29	21%	14%	29%	11,817	8,180	16,184
High Hazard	76	55%	46%	63%	30,975	26,069	35,761
2026 Mountain Pine Beetle Hazard Rating for Lodgepole Pine							
Low Hazard	35	25%	18%	33%	14,264	10,315	18,829
Moderate Hazard	22	16%	10%	23%	8,967	5,772	13,017
High Hazard	82	59%	50%	67%	33,416	28,516	38,101
2036 Mountain Pine Beetle Hazard Rating for Lodgepole Pine							
Low Hazard	36	26%	19%	34%	14,672	10,678	19,266
Moderate Hazard	25	18%	12%	25%	10,191	6,792	14,383
High Hazard	78	56%	47%	65%	31,790	26,879	36,543

Specifically for lodgepole pine dominated plots in 2016, typical conditions for stands based on hazard ratings are depicted in Table 2. The median values within these data are useful to consider when evaluating stands for harvesting.

Table 2. Common forest attributes by hazard rating in 2016 within lodgepole pine-dominated plots in the Pryor Mountains, Crow Indian Reservation

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
Low 2016 Mountain Pine Beetle Hazard Rating for Lodgepole Pine n = 1 plot*					
Trees per acre	484	484	n/a	484	484
Basal area per acre (feet^2 acre^{-1})	22	22	n/a	22	22
Stand density index	65	65	n/a	65	65
Lodgepole pine composition (%)	89%	89%	n/a	89%	89%
Lodgepole pine QMD (inches)	6.4	6.4	n/a	6.4	6.4
Canopy cover (%)	12	12	n/a	12	12
Height (feet)	13	13	n/a	13	13
Cubic volume (feet^3)	476	476	n/a	476	476
Merch. volume (board feet)	1,144	1,144	n/a	1,144	1,144
Moderate 2016 Mountain Pine Beetle Hazard Rating for Lodgepole Pine n = 12 plots					
Trees per acre	667	586	394	217	1,333
Basal area per acre (feet^2 acre^{-1})	105	78	62	28	204
Stand density index	242	185	142	75	480
Lodgepole composition (%)	83%	87%	15%	56%	100%
Lodgepole pine QMD (inches)	8.3	8.0	1.7	6.3	11.7
Canopy cover (%)	37	35	16	13	61
Height (feet)	30	30	12	12	47
Cubic volume (feet^3)	2,394	1,912	1,390	660	4,694
Merch. volume (board feet)	7,472	6,506	3,790	2,527	14,465
High 2016 Mountain Pine Beetle Hazard Rating for Lodgepole Pine n = 68 plots					
Trees per acre	742	656	510	155	2,847
Basal area per acre (feet^2 acre^{-1})	151	155	37	84	227
Stand density index	326	330	81	184	468
Lodgepole pine composition (%)	87%	89%	11%	59%	100%
Lodgepole pine QMD (inches)	9.6	9.4	1.7	7.0	13.9
Canopy cover (%)	47	48	10	29	79
Height (feet)	36	37	15	8	61
Cubic volume (feet^3)	3,824	3,872	961	2,224	5,914
Merch. volume (board feet)	14,476	14,086	3,967	8,189	23,436

*There was only one plot dominated by lodgepole pine with a low MPB hazard rating, therefore standard deviation calculations were not feasible

The spatial pattern of susceptibility was not clumped in any consistent pattern or portion of the Pryor Mountain study area plots in 2016 or any of the simulated years (Figure 1). Rather, the low and moderately susceptible areas were dispersed in the same areas that had highly susceptible plots. This suggests that prioritizing harvesting based on the geographic location of highly susceptible stands is not feasible.

Instead, prioritizing treatments in stands that exceed median basal area and QMD characteristics of highly susceptible plots (see Table 2) is suggested to reduce the abundance of those areas that can substantially amplify MPB populations and contribute to a landscape-scale outbreak.

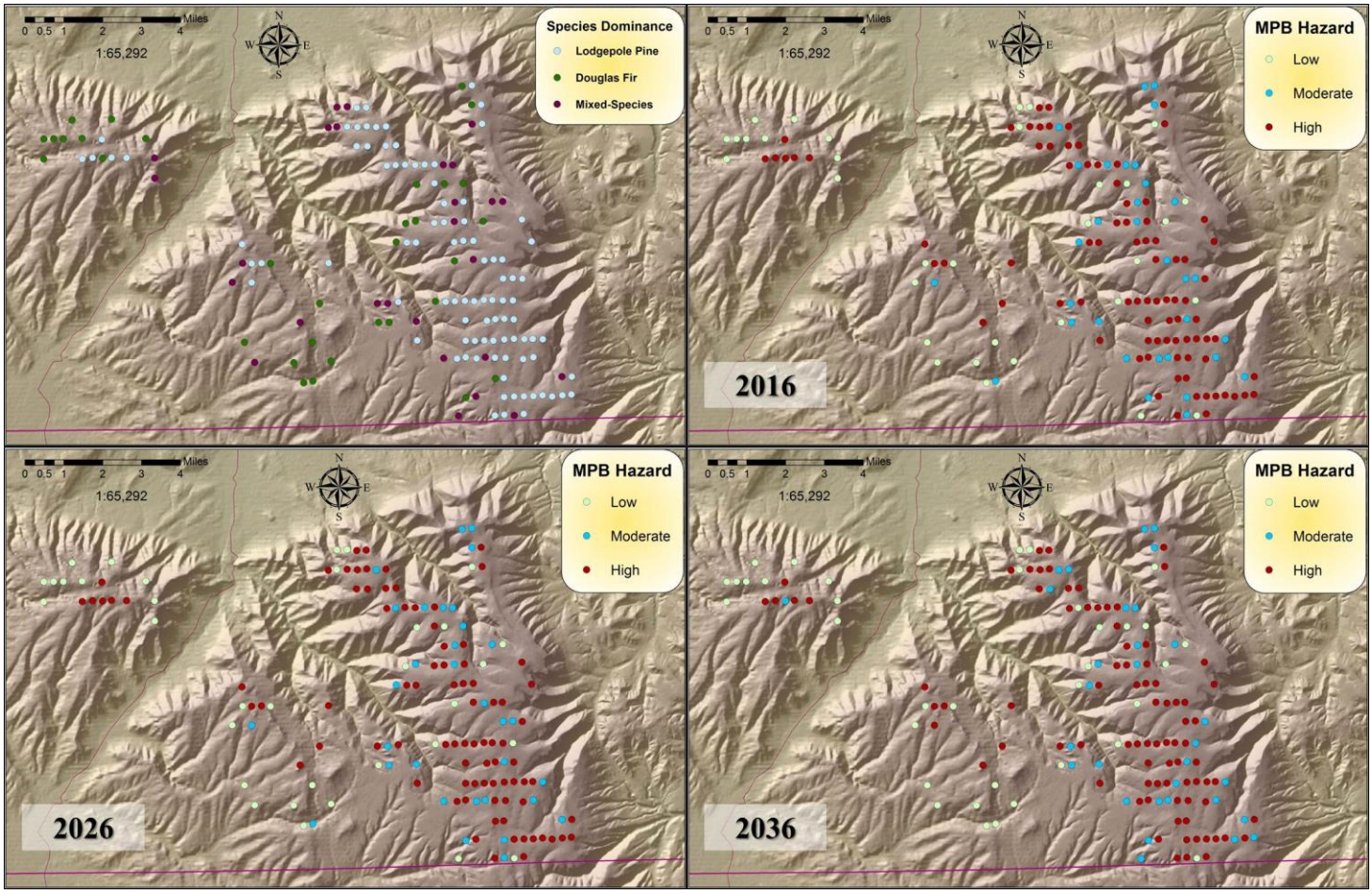

Figure 1. Spatial distribution of plots by species dominance and susceptibility class from 2016-2036 within the Pryor Mountains, Crow Indian Reservation.

Wolf Mountain Results

In the Wolf Mountains, ponderosa pines frequently dominated the species composition within plots that had moderate to high stocking levels and mid-sized stems. Forest attributes from 2016-2036, as well as mean forest attribute changes anticipated in the subsequent ten years, are presented in Appendix B. The plots surveyed were primarily rated as either being moderate or high hazard, with very few having a low susceptibility rating (Table 3). Near fifty thousand acres was estimated for each of the moderate and highly susceptible forested area surveyed. The proportion of area rated highly susceptible is anticipated to increase 11% from 2016 to 2026 and an additional 8% from 2026 to 2036.

Specifically for ponderosa pine dominated plots in 2016, typical conditions for stands based on hazard ratings are depicted in Table 3. The median values within these data are useful to consider when evaluating stands for harvesting.

The spatial pattern of susceptibility was not clumped in any consistent pattern or portion of the Wolf Mountain study area plots in 2016 or any of the simulated years (Figure 2). Rather, the moderate and highly susceptible areas were dispersed throughout the surveyed area. This suggests that prioritizing harvesting based on the geographic location of highly susceptible stands is not feasible.

Table 3. Plot and area distribution of forest susceptibility to bark beetles from 2016-2036 in the Wolf Mountains, Crow Indian Reservation

n = 275 plots established throughout 110,417 acres in grid distribution with 1 plot every 0.6 square miles

Forest Type	Plots	Percent of all Plots	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Area Estimate (acres)	Lower CI Estimate (acres)	Upper CI Estimate (acres)
Ponderosa pine	254	92%	89%	95%	101,985	97,785	105,128
Lodgepole pine	12	4%	2%	8%	4,818	2,506	8,281
Mixed Species	9	3%	2%	6%	3,614	1,667	6,758
2016 Bark Beetle Hazard Rating for Ponderosa Pine							
Low Hazard	17	6%	4%	10%	6,824	4,019	10,721
Moderate Hazard	118	43%	37%	49%	47,380	40,832	54,093
High Hazard	140	51%	45%	57%	56,213	49,511	62,894
2026 Bark Beetle Hazard Rating for Ponderosa Pine							
Low Hazard	19	7%	4%	11%	7,630	4,649	11,682
Moderate Hazard	86	31%	26%	37%	34,527	28,532	40,976
High Hazard	170	62%	56%	68%	68,260	61,602	74,631
2036 Bark Beetle Hazard Rating for Ponderosa Pine							
Low Hazard	18	7%	4%	10%	7,232	4,339	11,207
Moderate Hazard	64	23%	18%	29%	25,694	20,328	31,712
High Hazard	193	70%	64%	76%	77,491	71,109	83,398

Instead, prioritizing treatment stands that exceed median basal area and QMD characteristics of highly susceptible plots (see Table 4) is suggested to reduce the abundance of those areas that can substantially amplify MPB populations and contribute to a landscape-scale outbreak.

Discussion

The hazard or susceptibility information provided has quantified the magnitude of forested bark beetle habitat available for colonization. In both the Pryor and Wolf Mountains, there is ample forested area with stand conditions suitable to promote bark beetle-caused tree mortality. Without treatment, the amount of susceptible host material is projected to increase in abundance over the subsequent two

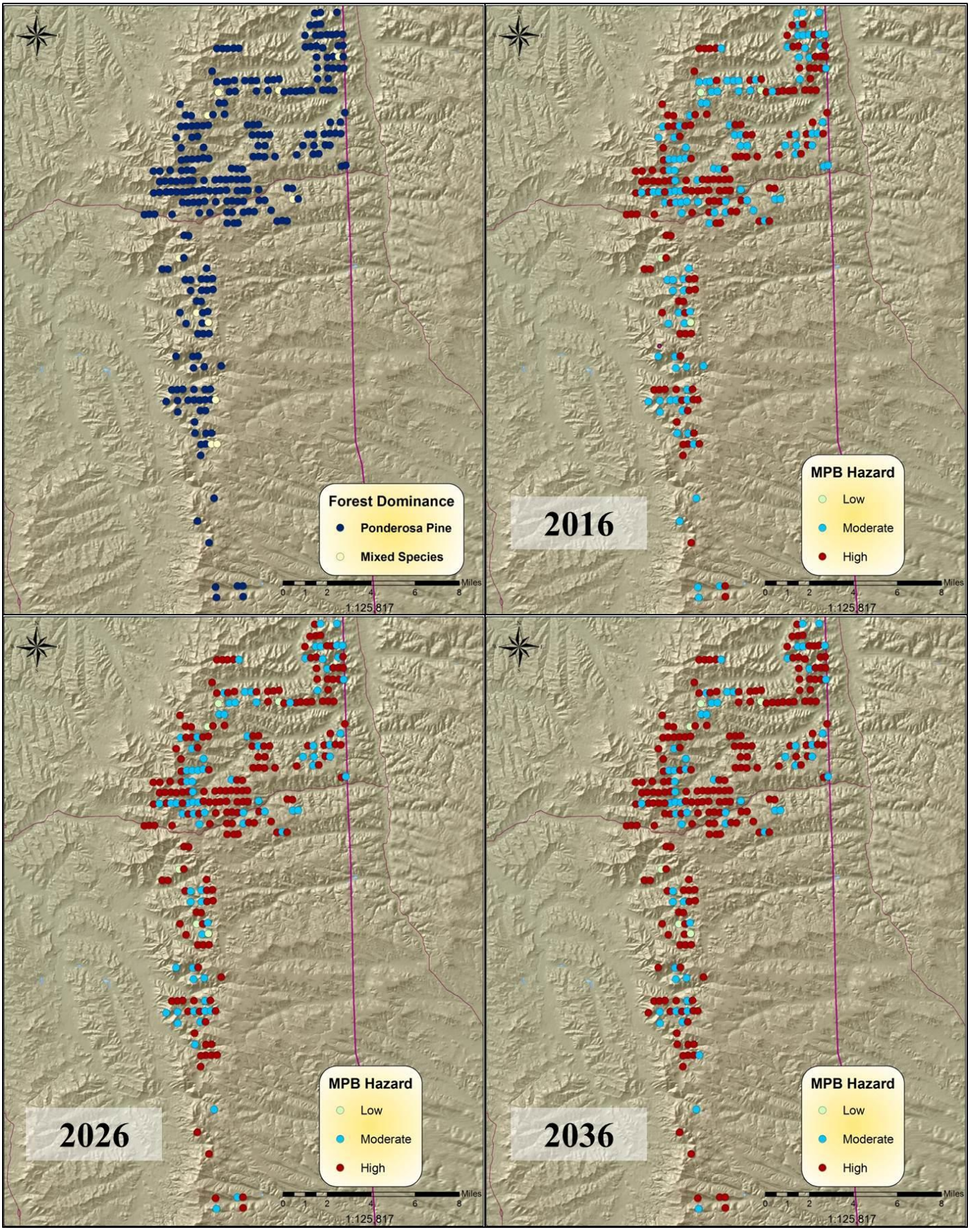

Figure 2. Spatial distribution of plots by species dominance and susceptibility class from 2016-2036 within the Wolf Mountains, Crow Indian Reservation

decades. If coupled with a severe and prolonged drought, these stand conditions are sufficient to support widespread bark beetle outbreaks.

LODGEPOLE PINE IN THE PRYOR MOUNTAINS

Substantial MPB outbreaks occurred throughout Montana over the past decade in lodgepole pine forest types (Gannon and Sontag 2009). In the most impacted areas, 80-90% lodgepole pine mortality was observed. Analysis of the Pryor Mountain CFI plot data indicate that majority of the lodgepole pine forested area was at a moderate to high susceptibility to beetles during the mid-2000s and is becoming more suitable as these stands grow through time. It is not known exactly why substantial MPB activity did not occur in the Pryor Mountains during this last drought period; however, it is known that the structural conditions to support landscape-scale outbreaks are present within the Pryor Mountains. MPB activity did increase in this location following the severe drought year of 2012; however, it did not surpass incipient stage into a widespread epidemic (Safranyik and Carroll 2006) after 2013 and 2014 had near normal precipitation. It is anticipated that a substantial MPB outbreak is likely to occur during the next protracted drought period.

Table 4. Common forest attributes by hazard rating in 2016 within ponderosa pine-dominated plots in the Wolf Mountains, Crow Indian Reservation

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
Moderate 2016 Bark Beetle Hazard Rating for Ponderosa Pine n = 115 plots					
Trees per acre	242	69	548	5	4,422
Basal area per acre (feet^2 acre^{-1})	54	55	25	1	166
Stand density index	105	99	66	3	401
Ponderosa pine composition (%)	94%	99%	10%	53%	100%
Ponderosa pine QMD (inches)	13.6	13.2	4.3	6.1	31.3
Canopy cover (%)	23	21	13	1	73
Height (feet)	42	39	21	6	98
Cubic volume (feet^3)	1,278	1,308	595	20	2,807
Merch. volume (board feet)	5,654	5,780	3,048	61	11,956
High 2016 Bark Beetle Hazard Rating for Ponderosa Pine n = 139 plots					
Trees per acre	514	265	607	39	3,763
Basal area per acre (feet^2 acre^{-1})	130	125	34	81	234
Stand density index	257	242	91	116	562
Ponderosa pine composition (%)	92%	97%	10%	56%	100%
Ponderosa pine QMD (inches)	14.0	13.7	3.1	8.2	22.1
Canopy cover (%)	43	43	12	21	78
Height (feet)	38	36	20	7	81
Cubic volume (feet^3)	3,282	3,111	916	1,639	6,139
Merch. volume (board feet)	14,971	13,890	4,860	6,523	29,682

Note: There were no ponderosa pine-dominated plots within the Wolf Mountains with a Low bark beetle hazard rating

Regeneration harvesting activities (i.e. clearcutting, patch cutting, and/or variable retention harvesting) can promote age class diversity and resilience to severe and widespread MPB outbreaks (Whitehead et al. 2007; Whitehead 2010; Egan et al. 2014). If possible, distributing harvesting units spatially throughout the extent of the area designated for timber management can further reduce landscape-scale susceptibility to MPB-attack. This type of patch cutting has been shown beneficial to increase age diversity and resilience to MPB disturbances (Johnson et al. 2014). Additionally, lodgepole pine regeneration harvesting studies in the Tenderfoot Creek Experimental Forest indicate this management can reduce the potential for active crown fire spread; however, this study also showed a tradeoff where treated areas had the potential for increased surface fireline intensities and crown fire initiation due to increases in surface fuel loadings created with the harvesting activities (Crotteau et al. 2015).

The risk of MPB and wildfire disturbances can be compared to benefits of accumulating merchantable timber volume over the next decade under a no action scenario assuming minimal disturbance (see Appendix A: Tables A1 and A2).

It is recommended that when prioritizing units for harvesting, tribal foresters focus on those stands that exceed the median values (basal area, lodgepole pine QMD, and % lodgepole pine) summarized for highly susceptible lodgepole pine stands within the Pryor Mountains. Dispersing these treatments throughout the extent of lodgepole pine in this area can enhance resilience by breaking up the contiguous patches of mature, susceptible forest.

PONDEROSA PINE IN THE WOLF MOUNTAINS

MPB and associated bark beetle outbreaks have also impacted ponderosa pine forest types throughout Montana in the past decade with most mortality occurring in second growth stands (Gannon and Sontag 2009). Outbreaks in this system vary from those in lodgepole pine most notably in their severity, as mortality typically does not exceed fifty percent of all available ponderosa pines (Randall et al. 2011). MPB outbreaks are rare within ponderosa pine stands in the Wolf Mountains; however, *Ips* spp. epidemics are not. For example, *Ips* spp. populations caused numerous pockets of mortality following the severe drought year in 2012 throughout ponderosa pines located in areas with poor site quality (Egan 2014b). Even though the timber production areas in the Wolf Mountains were not impacted, this analysis shows virtually all of the pine stands in the survey area are moderately or highly susceptible to beetle-attack. Thus, low to moderate levels of tree mortality (up to 45% of stems > 5" DBH) should be anticipated for this area during subsequent severe and protracted drought periods (Randall et al. 2011).

Multiple options are available to reduce stand susceptibility to bark beetle-attack. Partial harvesting, or stand-level thinning from below operations, that enhances spacing between residual trees is an effective way to promote resilience to bark beetle-attack (Schmid and Mata 2007; Egan et al. 2010; Egan et al. 2014). This treatment can also promote large-diameter ponderosa pines which have been shown to have enhanced resilience to bark beetle-attack especially after they exceed 20" DBH (Randall et al. 2011; Egan 2013).

Another available management option combines traditional regeneration and partial harvesting options throughout a stand to create vertical (age) and horizontal (spacing) diversity. This kind of treatment retains clumps of vegetation in some areas, enhances spacing around individual stems in others, and creates openings for recruitment in additional patches. This mixture of treatments, known as ICOs (named for the retention tree pattern of intermixed individual trees, clumps, and openings), has been outlined to enhance forested resilience and provide for ponderosa pine ecosystem process restoration (Churchill et al. 2013a; Churchill et al. 2013b). For a comprehensive discussion on the benefits of this treatment strategy see MFO-TR-13-09 (Egan and Jackson 2013, pages 6-8).

The risk of bark beetle and wildfire disturbances can be compared to benefits of accumulating additional merchantable timber volume over the next decade under a no action scenario assuming minimal disturbance (see Appendix B: Tables B1 and B2).

Forest Health Protection staff is available to assist in developing long-term management strategies for tribal forest resources on the Crow Indian Reservation.

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Appendix A.

Table A1. Pryor Mountain mean (standard deviation) stand variable estimates by stand type at ten year intervals from 2016 to 2036.

Variable	Year	Lodgepole Pine Dominated Plots	Douglas-fir Dominated Plots	Mixed Species Plots
Density (trees acre^{-1})	2016	728 (490)	516 (511)	1419 (1183)
	2026	890 (556)	624 (570)	1715 (1187)
	2036	825 (474)	594 (555)	1651 (1034)
Basal Area (feet^2 acre^{-1})	2016	143 (46)	163 (64)	109 (68)
	2026	160 (49)	175 (71)	139 (70)
	2036	178 (53)	196 (71)	160 (70)
Stand Density Index	2016	310 (99)	315 (126)	227 (169)
	2026	354 (107)	349 (143)	358 (171)
	2036	381 (114)	380 (144)	400 (165)
QMD (inches)	2016	6.7 (2.1)	9.7 (6.8)	4.2 (2.3)
	2026	6.4 (1.9)	8.5 (3.0)	4.1 (1.9)
	2036	6.9 (2.0)	9.2 (3.2)	4.4 (1.8)
Height (feet)	2016	35 (15)	36 (16)	17 (11)
	2026	30 (12)	28 (12)	17 (8)
	2036	33 (12)	32 (12)	19 (8)
Merch. vol. (board feet)	2016	13,274 (4,824)	14,594 (6,565)	6,878 (5,709)
	2026	15,868 (5,462)	17,366 (8,078)	9,089 (6,594)
	2036	18,533 (6,193)	21,389 (8,886)	10,557 (7,266)
Cubic volume (feet)	2016	3,571 (1,192)	3,545 (1,505)	2,060 (1,488)
	2026	4,102 (1,321)	4,045 (1,786)	2,712 (1,632)
	2036	4,695 (1,473)	4,802 (1,888)	3,156 (1,718)
% Basal area Douglas-fir	2016	3.3 (7.2)	77.3 (15.1)	21.4 (17.3)
	2026	3.8 (7.7)	78.5 (15.1)	21.0 (18.2)
	2036	4.3 (8.1)	81.4 (14.4)	19.5 (18.2)
% Basal area ponderosa pine	2016	0.3 (2.4)	0 (0)	0.4 (1.4)
	2026	0.3 (2.3)	0 (0)	0.4 (1.6)
	2036	0.3 (2.2)	0 (0)	0.5 (1.7)
% Basal area lodgepole pine	2016	86.1 (11.9)	5.0 (10.3)	13.3 (16.3)
	2026	85.4 (12.1)	4.3 (9.2)	13.3 (15.2)
	2036	86.7 (12.5)	5.0 (9.9)	12.8 (15.5)

Table A2. Mean (standard deviation) change in stand variables between 2016 and 2026 by dominant species in the Pryor Mountains, Crow Indian Reservation

Stand Variables	Lodgepole Pine Dominated Plots	Douglas-fir Dominated Plots	Mixed Species Dominated Plots
Number of plots (n)	81	32	26
Trees per acre	161.8 (105.4)	136.4 (88.3)	177.2 (123.9)
Basal area ($feet^2$ $acre^{-1}$)	16.9 (6.2)	20.3 (10.9)	22.1 (13.6)
Stand density index	43.4 (14.4)	51.2 (21.1)	58.0 (32.4)
Canopy cover (%)	4.7 (2.5)	4.3 (3.7)	8.6 (7.3)
QMD (inches)	-0.4 (0.4)	-1.0 (1.0)	0.001 (0.5)
Height (feet)	-4.8 (3.7)	-7.2 (6.6)	-0.6 (4.2)
Cubic volume ($feet^3$)	531 (169)	722 (233)	480 (304)
Merchantable volume (board feet)	2,594 (1,017)	3,749 (1,262)	1,645 (1,186)

Appendix B.

Table B1. Wolf Mountain mean (standard deviation) stand variable estimates by stand type at ten year intervals from 2016 to 2036.

Variable	Year	Lodgepole Pine Dominated Plots	Ponderosa Pine Dominated Plots	Mixed Species Plots
Density	2016	1,076 (689)	390 (595)	313 (317)
(trees acre^{-1})	2026	1,201 (737)	473 (582)	859 (1,285)
	2036	1,127 (681)	441 (526)	874 (1,098)
Basal Area	2016	142 (62)	95 (49)	47 (54)
(feet^2 acre^{-1})	2026	171 (61)	113 (56)	75 (66)
	2036	191 (69)	129 (63)	104 (87)
Stand	2016	323 (125)	188 (110)	101 (105)
Density	2026	394 (134)	230 (127)	179 (157)
Index	2036	427 (151)	254 (128)	240 (204)
QMD	2016	6.0 (3.2)	10.5 (5.0)	4.7 (4.5)
(inches)	2026	5.9 (2.4)	8.4 (2.9)	4.6 (3.5)
	2036	6.3 (2.4)	9.2 (3.0)	5.2 (3.6)
Height	2016	26 (15)	40 (20)	22 (21)
(feet)	2026	24 (11)	25 (10)	20 (14)
	2036	27 (11)	29 (10)	22 (14)
Merch. vol.	2016	13,856 (6,789)	10,752 (6,218)	4,599 (8,524)
(board feet)	2026	16,998 (6,967)	13,224 (7,291)	6,597 (9,564)
	2036	18,920 (7,613)	16,007 (8,475)	8,538 (11,156)
Cubic volume	2016	3,541 (1,658)	2,375 (1,271)	1,093 (1,658)
(feet^3)	2026	4,318 (1,629)	2,870 (1,465)	1,653 (1,885)
	2036	4,845 (1,820)	3,396 (1,671)	2,173 (2,206)
% Basal area	2016	3.6 (8.4)	0.1 (1.3)	0.6 (1.8)
Douglas-fir	2026	3.9 (8.5)	0.1 (11)	0.4 (1.4)
	2036	3.9 (8.4)	0.1 (1.1)	0.3 (1.3)
% Basal area	2016	0 (0)	93.0 (9.9)	19.1 (22.8)
ponderosa	2026	0.2 (0.6)	92.5 (10.5)	19.9 (21.2)
pine	2036	0.2 (0.6)	92.2 (10.9)	20.6 (20.2)
% Basal area	2016	82.2 (13.9)	0 (0)	3.0 (9.1)
lodgepole	2026	81.8 (12.7)	0 (0)	6.7 (15.5)
pine	2036	78.9 (16.2)	0 (0)	6.0 (12.7)

Table B2. Mean (standard deviation) change in stand variables between 2016 and 2026 by dominant species in the Wolf Mountains, Crow Indian Reservation

Stand Variables	Ponderosa Pine Dominated Plots	Lodgepole Pine Dominated Plots	Mixed Species Dominated Plots
Number of plots (n)	254	12	9
Trees per acre	96.8 (73.9)	223.1 (108.4)	54.9 (52.8)
Basal area ($feet^2$ $acre^{-1}$)	17.2 (11.4)	19.8 (13.5)	10.6 (10.5)
Stand density index	43.1 (23.0)	55.1 (29.5)	26.4 (23.5)
Canopy cover (%)	4.7 (3.7)	8.0 (7.0)	6.5 (6.3)
QMD (inches)	-0.3 (2.9)	-0.4 (0.7)	-2.1 (1.6)
Height (feet)	-14.3 (16.1)	-3.2 (5.4)	-3.8 (12.1)
Cubic volume ($feet^3$)	500 (266)	496 (272)	225 (240)
Merchantable volume (board feet)	2,476 (1,451)	1,938 (1,514)	815 (1,352)